W72-11935

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# EFFECTS OF FEEDLOT RUNOFF ON WATER QUALITY OF IMPOUNDMENTS

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INPUT TRANSACTION FORM

1. Report No. | 2. | 3. Accession No. W72-11935

4. Title
EFFECTS OF FEEDLOT RUNOFF ON WATER QUALITY OF IMPOUNDMENTS,

5. Report Date
6.
8. Performing Organization Report No.

7. Author(s)
Duffer, W. R., Kreis, R. D., and Harlin, C. C. Jr.

10. Project No. EPA Program 16080GGP07/71

9. Organization Environmental Protection Agency
[redacted], Robert S. Kerr Water Research Center
Ada, Oklahoma

11. Contract/Grant No.

13. Type of Report and Period Covered

12. Sponsoring Organization Water Pollution Control Research Series

15. Supplementary Notes ~~Effects of feedlot runoff on water quality of impoundments,~~ ~~Project # 16080 GGP~~, July 1971, 53 pp., 13 fig., 7 tab., 9 ref., 4 append.

16. Abstract

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17a. Descriptors

*Feed lots
*Reservoirs, *fishkill, * ammonia, *dissolved oxygen, *runoff, organic wastes, nutrients, phytoplankton, light penetration, zoo plankton, Benthos
*Farm wastes, Water pollution sources, Cattle

17b. Identifiers

~~*beef cattle, [redacted] feedlots, macrobenthos,~~ solids concentration

Copy available from GPO Sup Doc EPA-16080 GGP $0.65 ; microfiche 01/71 from NTIS as PB 211 124, $0.95.

17c. COWRR Field & Group 05C

| | | | |
|---|---|---|---|
| 18. Availability Supt. of Documents U.S. Gov't. Print. Off. Washington, D.C. 20402 | 19. Security Class. (Report) | 21. No. of Pages | Send To: WATER RESOURCES SCIENTIFIC INFORMATION CENTER U.S. DEPARTMENT OF THE INTERIOR WASHINGTON, D. C. 20240 |
| | 20. Security Class. (Page) | 22. Price | |

Abstractor Steven Dorland | Institution Iowa State University

GPO 913.261

WRSIC 102 (REV JUNE 1971)

# EFFECTS OF FEEDLOT RUNOFF ON WATER QUALITY OF IMPOUNDMENTS

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ENVIRONMENTAL PROTECTION AGENCY

Project #16080 GGP

July 1971

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## ABSTRACT

A study was conducted to determine the effects of rainfall runoff from a beef cattle feedlot on the water quality of a small impoundment. Changes in chemical concentration of impounded water and changes in the community structure of aquatic organisms were measured and related to the amount and composition of feedlot runoff received. Water quality changes were also monitored in a nearby reservoir which received no feedlot runoff to serve as a control. Rainfall from feedlots was retained in collection ponds and pumped into the impoundment over a relatively short period of time, creating in effect a "slug" discharge condition. Changes in chemical concentration or population structure of organisms were not apparent for discharges of about one-part feedlot runoff to 40 parts receiving water. Runoff discharges for two pumping periods with each contributing one-fourth of the volume of the receiving water were shown to degrade water quality in the impoundment. Several significant chemical and biological changes occurred. The concentration of salts, solids, oxygen-demanding organic compounds and nutrients increased. Population levels decreased for organisms having negative tolerances for low dissolved oxygen and high ammonia concentrations. The most dramatic reduction in the biological community was the suffocation of about 90% of the game fish in the impoundment. Reduction in population levels of "stressed" organisms was followed by increased productivity of phototropes in response to higher nutrient concentrations.

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## SECTION I

## CONCLUSIONS

The farm pond and the reservoir which receive feedlot runoff responded in a similar manner to large volume discharges of feedlot waste effluents. Physical and chemical changes consisted of reduced limit of visibility; increased conductivity and oxygen demand; and higher concentrations of solids, chlorides, nitrogen, and phosphorus. In general, biological populations became less diverse. Greater densities of fecal coliform, fecal streptococci, and total coliform resulted following periods of intensive rainfall runoff from the watershed rather than following periods of discharge of feedlot effluents.

The most dramatic biological change was a fish kill following a waste discharge in April which equaled about one-quarter of the volume of the receiving reservoir. Fish suffocated due to the combined effects of depressed dissolved oxygen levels and high ammonia concentrations which inhibited the oxygen absorption capabilities of hemoglobin in the blood.

Population levels of benthic organisms, zooplankton, and phytoplankton were severely reduced in the small farm pond following major feedlot waste discharge periods. The primary factor contributing to the reduction of population levels of benthos and zooplankton was a low concentration of dissolved oxygen, while the decrease in populations of phytoplankton may have been caused by high ammonia concentrations.

Changes in population levels for invertebrate organisms were similar for the farm pond and the receiving reservoir immediately following major waste discharges with the exception of phytoplankton. Reductions in the benthic and zooplanktonic populations in the receiving reservoir were not as severe as those in the farm pond due to greater dilution of wastes. Even with increased dilution, nutrient levels were sufficiently high to create optimal conditions for growth of phytoplankton. Following the 1970 March discharge, population levels increased to bloom proportions causing severe fluctuations in diel dissolved oxygen concentrations which continued for about three months. Reduction of the high oxygen demand created by feedlot wastes and phytoplanktonic respiration was accompanied by an increase in populations of benthic organisms and zooplankton to levels exceeding those prior to the discharge.

Due to the varying influence of environmental factors and concentration of pollutants, the absolute minimum amount of feedlot waste effluent that will damage aquatic life in a reservoir was not established. The volumetric ratio of waste discharge to receiving water was the same for the two major discharge periods. Degradation of water quality and the resulting harmful effects on the entire spectrum of aquatic life were more severe following the March discharge than following the October 1970 discharge.

## SECTION II

## RECOMMENDATIONS

1. Present volumes of rainfall runoff, draining to surface waters from feedlots, should be significantly reduced.

2. Feedlot waste management practices which would reduce the concentration of pollutants in rainfall runoff should be established.

3. In addition to considerations such as availability of feed, animals, and markets, future establishment of feedlot operations should require incorporation of geographical and topographical features which are conducive to efficient control of wastes and runoff drainage.

4. Waste treatment methods should be developed and tested for application to feedlot rainfall runoff which drains to surface waters.

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SECTION III

# INTRODUCTION

## Objectives

Serious water pollutional sources are created by confining large numbers of commercial feeder animals in a small area. The number of beef cattle feedlots are growing at a rate of about 10 percent annually nationwide and 30 percent annually in the plains area of Texas, Oklahoma, Colorado, Nebraska, and Kansas. Nearly all of this growth has been in the form of 5,000- to 100,000-head capacity feedlots. As with the concentration of people in cities, the concentration of animals in a small area produces massive environmental problems.

One beef animal will produce over a half-ton of manure on a dry weight basis during its stay of 120-150 days in a feedlot. This is deposited on as little as 100 to 200 square feet per animal, resulting in an enormous waste disposal problem for the feedlot operator. Runoff, resulting from rainfall which comes in contact with the manure, carries high concentrations of oxygen-demanding materials, solids, and nutrients into surface water. Pollutants are often present in concentrations of 10 to 100 times those of raw municipal wastes. Uncontrolled feedlot runoff introduced into streams and reservoirs can result in oxygen depletion, fish kills, and other undesirable conditions.

The objective of this study was to determine the effects of wastes transported in rainfall runoff from a beef cattle feedlot on the water quality of an impoundment. Areas of consideration were chemical degradation of water quality and structural changes in the communities of aquatic organisms. A detailed analysis of the characterization of the feedlot wastes involved in this study was presented by Kreis, Scalf, and McNabb.[1]

## Description of Study Area

The location selected for this study was adjacent to an operating 12,000-head beef cattle feedlot located in Colin County, about ten miles northeast of McKinney, Texas. Figure 1 shows the layout of the feedlot and study area. The study area is comprised of a small farm pond, a flood control reservoir which receives feedlot runoff (R-11), and a flood control reservoir which does not receive feedlot drainage (R-10). Flow of feedlot runoff through the system is indicated by arrows.

Runoff from the feedlot is stored in four holding ponds. Extraneous drainage is diverted around the feedlot so that the holding pond receives rainfall runoff only from the feed pens. In order to prevent development of objectionable odors from the holding ponds, runoff is pumped into a 12,000-foot-long ditch which discharges into the farm pond. Overflow from the farm pond empties into a flood control reservoir having a surface area of about 45 acres.



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Sampling Stations 3, 4, 5, 9, and 10 were established to determine the volume of feedlot runoff and the effects of runoff-carried pollutants on the water quality of the farm pond and the receiving reservoir. Stations 6, 7, and 8 were also established in a nearby reservoir which did not receive feedlot runoff to serve as a control. The surface area of the control reservoir was 30 acres. Additional sampling stations 1 and 2 were located near the primary drawdown of each reservoir.

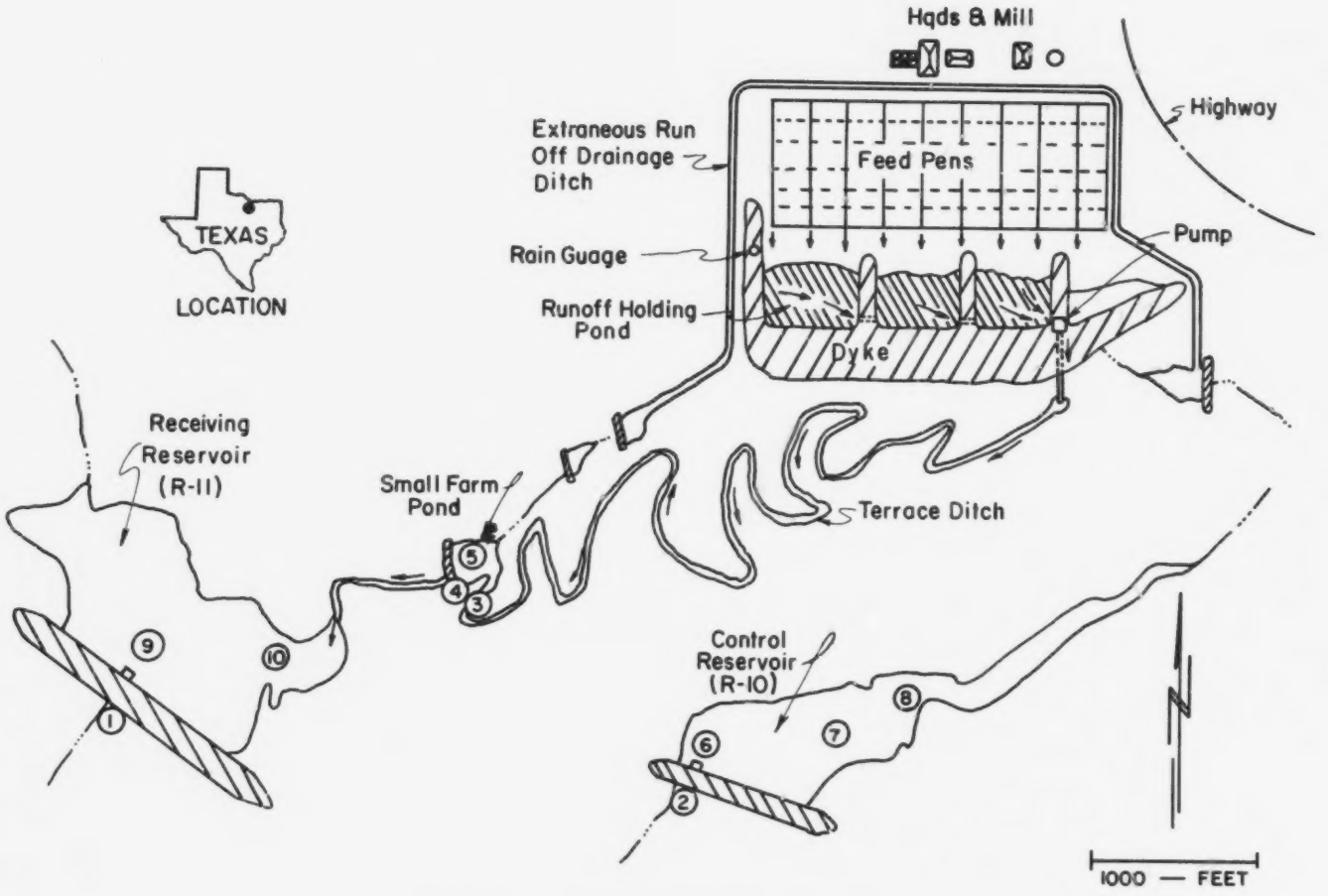


FIGURE 1. FEEDLOT AND STUDY AREA

## SECTION IV

## METHODS

Biological, microbiological, and chemical samples were collected, and physical parameters were measured seven times between August 1969 and July 1970 in the small farm pond and in the two flood control reservoirs. An initial sample collection was succeeded by ad hoc collections following periods of drainage of feedlot runoff to the receiving reservoir and by congruous surveillance collections at a maximum of three-month intervals. Samples for chemical analysis were collected near the surface at the farm pond and all reservoir stations. In addition, samples were collected near the bottom at Stations 7 and 9. During periods of flow, samples for chemical analysis were collected from the primary drawdown of both reservoir discharges, the ditch influent and effluent, and the farm pond effluent (Stations 1 through 4).

Biological forms sampled included: benthic macroinvertebrates, net zooplankton, and phytoplankton. Three Ponar dredge samples were collected at each station to evaluate changes in the communities of benthic macroinvetebrates. Two vertical Wisconsin net tows were made at each station to collect net zooplankton. To enumerate phytoplankton, a 200 ml sample of water was collected from the surface at each station and near the bottom at Stations 7 and 9. All plankton samples were preserved with 10 percent formalin.

Ponar dredge samples were collected and analyzed according to methods described for the Peterson dredge.[2] Quantitative analyses of net zooplankton and phytoplankton were according to the method of Weber.[3] Microbiological analyses were performed for total coliforms, fecal coliforms, and fecal streptococci by the membrane filter method using standard techniques.

Analysis of water samples for pH, conductivity, total alkalinity, total solids, total suspended solids, total dissolved solids, chloride, nitrate (automated technique), ammonia, ortho-phosphate, total phosphate, chemical oxygen demand (COD), and 5-day biochemical oxygen demand ($BOD_5$) were according to Federal Water Quality Administration Methods.[4] Total organic nitrogen was analyzed by Technicon Auto-Analyzer Methodology, which was periodically checked by the preceding methods.[5] Total organic carbon (TOC) was analyzed according to the method of VanHall, Safrauko, and Stenger.[6]

Dissolved oxygen and temperature were measured at two-foot depth intervals during each survey with a Weston and Stack, Model 300, Dissolved Oxygen Analyzer. Water transparency was measured with a standard 8-inch Secchis disc.

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Flow volumes were continuously measured at Stations 3 and 4 with Stevens, Model F-1, 8-day stage recorders, installed on a Parshall 18-inch flume and a 150° V-notch weir, respectively. Reservoir capacity and overflow volumes were continuously monitored with Stevens, Model F-1, 8-day recorders which were installed on the primary drawdown structure of each flood control reservoir. Rainfall was recorded with a weighing, continuous recording raingauge.

## SECTION V

## RESULTS

Feedlot runoff constituted 42% of the 133 acre-feet of drainage from the small farm pond to the receiving reservoir. This runoff contributed over 95% of the chlorides; 75% of the total organic carbon, total organic nitrogen, and total suspended solids; 65% of the total- and ortho-phosphate, ammonia, total solids, and total alkalinity; and 60% of the COD and $BOD_5$ transported from the farm pond to the receiving reservoir (Appendix Table 1).

The volume relationship of feedlot runoff to the receiving reservoir during each pumping period is presented in Figure 2. The September and November pumping periods represent the greatest dilution of feedlot wastes in the reservoir. The ratio of the volume of runoff to the volume of the receiving reservoir is 1:4 for both the October and March pumping periods.

### Biological and Microbiological Changes

The most dramatic change in the receiving reservoir was suffocation of a large proportion of the game fish. These fish began dying on April 7 and the kill continued through April 11. During this period, over 1,000 game, forage, and rough fish were killed (Figure 3). About 95% of the total fish killed were game species.

The average number of benthic macroinvertebrates per genera collected from the small farm pond decreased 97% from the August to the October sampling periods (Figure 4). This average remained below 70 organisms per genera until the May sampling period, when it increased from 10 to 590 organisms per genera. A similar but more subtle trend was observed in the receiving reservoir, where the October decrease was equivalent to 60% of the population collected in August. The April-May increase (from 58 to 376 organisms per genera) was preceded by a 50% decrease in the average number of organisms per genera collected during the February and April sampling periods. The average number of organisms collected from the control reservoir ranged from 160 to 300 organisms per genera throughout the study period.

Both the farm pond and the reservoir receiving feedlot runoff maintained a higher number of phytoplanktonic organisms per genera than the control reservoir. The average number of phytoplankters per genera per ml collected from the farm pond decreased from 560 in August to 418 in October, then increased to 1608 in December (Figure 5). Between February and April, the number of organisms per genera decreased 50% followed by an increase of 640 organisms per genera in May. This trend, however, was not observed in the phytoplanktonic community of the receiving reservoir. Instead, the number of organisms per genera increased in October and April, then decreased in December and May.

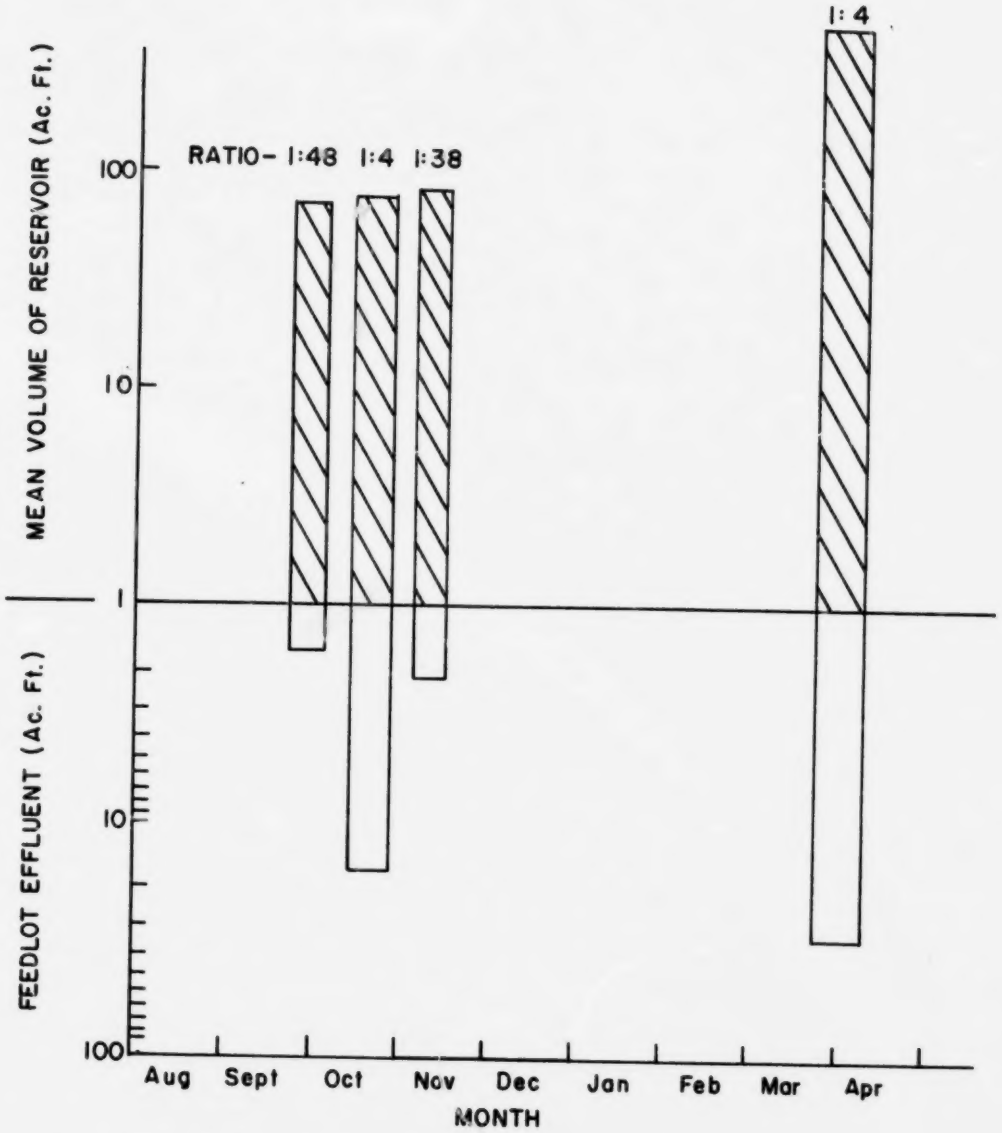



FIGURE 2. RELATIONSHIP OF WASTE VOLUME TO MEAN VOLUME OF RECEIVING RESERVOIR DURING PUMPING

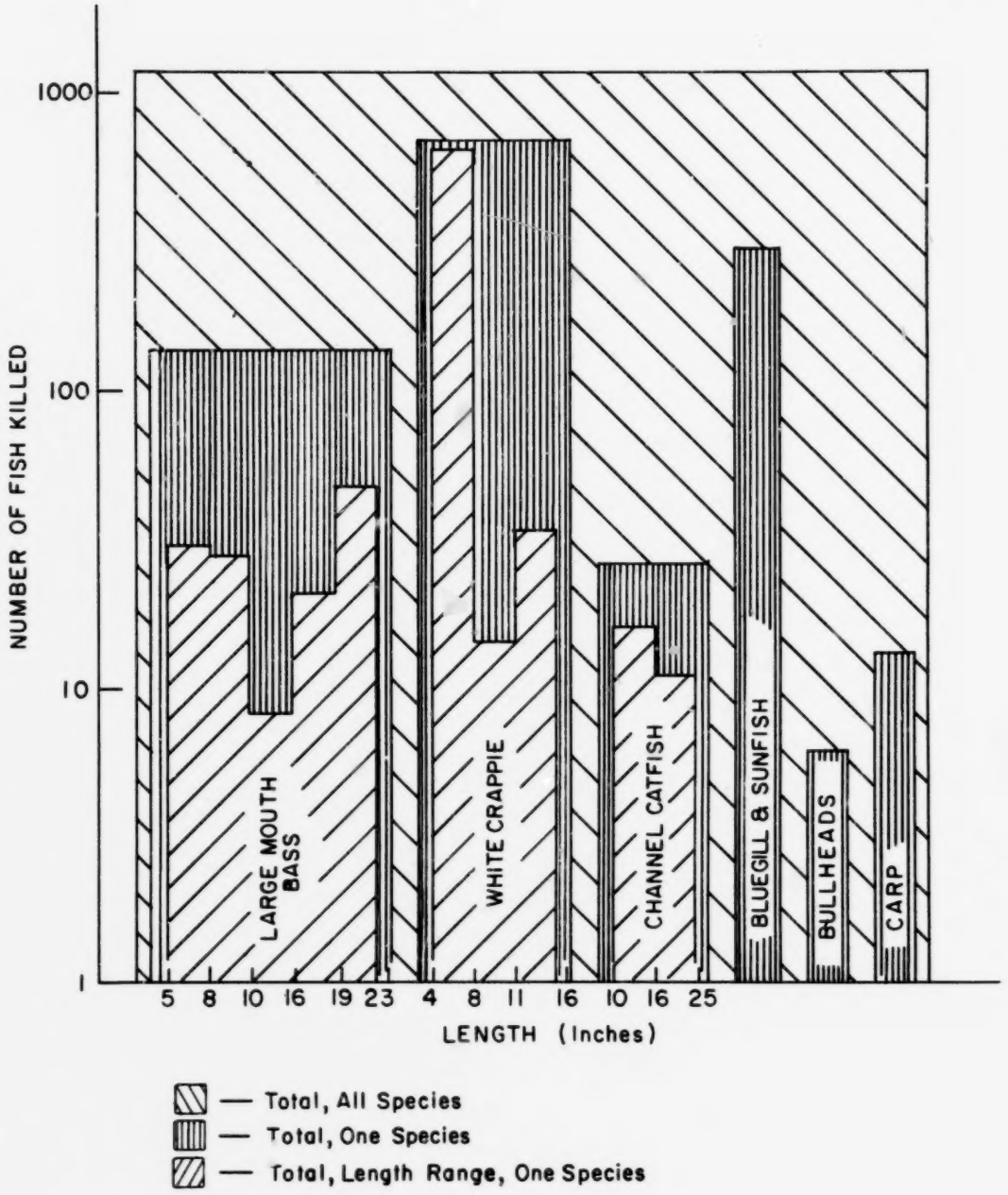



FIGURE 3. NUMBER, TYPE, AND SIZE OF FISH KILLED IN THE RECEIVING RESERVOIR

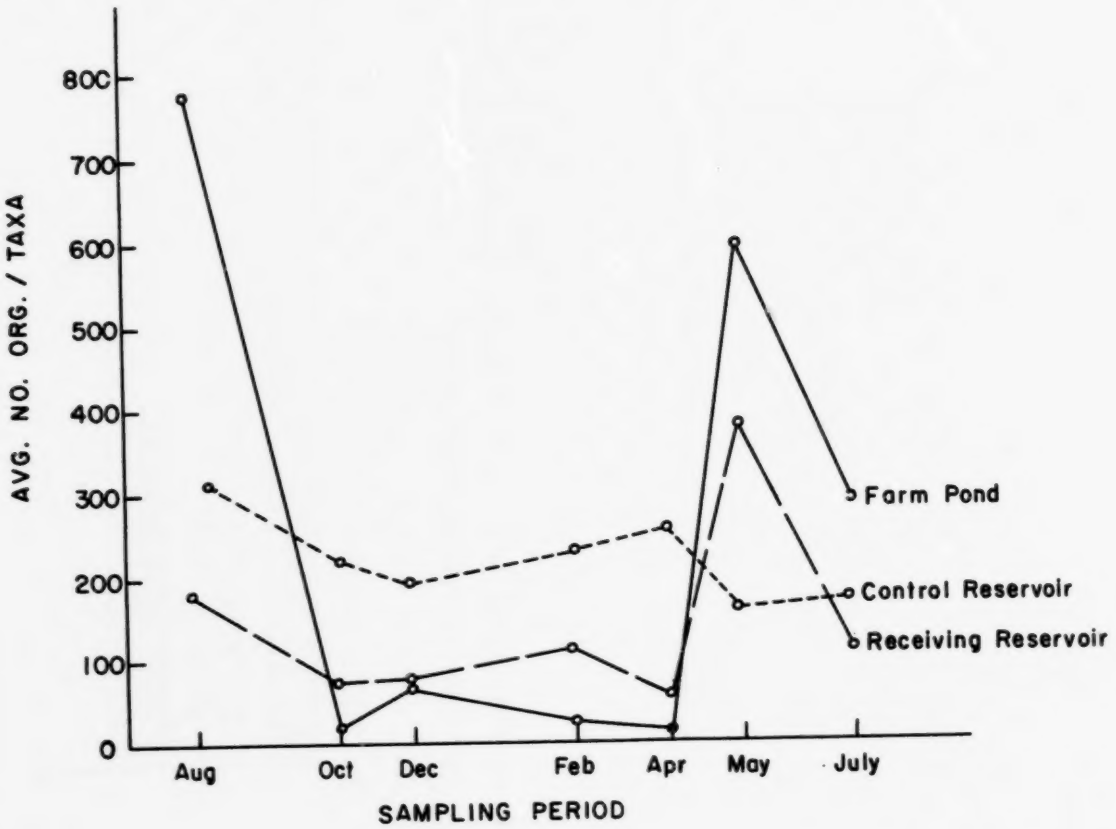



FIGURE 4. AVERAGE NUMBER OF BENTHIC MACROINVERTEBRATES PER SQUARE METER PER TAXA (BASED ON APPENDIX FIGURE I )

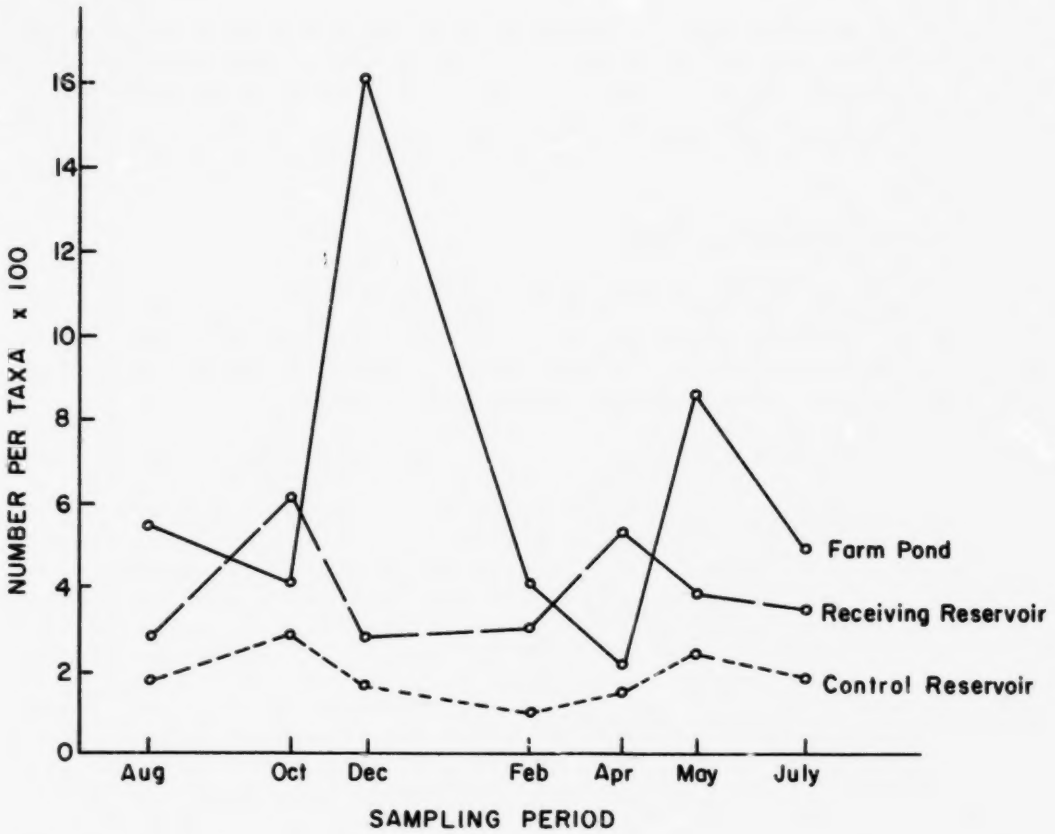



FIGURE 5. AVERAGE NUMBER OF PHYTOPLANKTERS PER MILLILITER PER TAXA
(BASED ON APPENDIX FIGURE 2)

Population fluctuations of zooplankton in the receiving reservoir were comparable to those of the benthos (compare Figure 6 and Appendix Figure 1). The most diminutive population sampled in the receiving reservoir was 7.3 zooplankters per liter representing 3 genera collected on April 9, 1970.

Analysis of microbiological samples revealed increases in total coliform, fecal coliform, and fecal streptococci during the October sampling period in the farm pond and both reservoirs and during the February sampling period only in the two reservoirs (Table I). Fecal streptococci increased and total coliform and fecal coliform decreased in the farm pond in February.

Chemical and Physical Changes

Dissolved oxygen levels in the farm pond were reduced to zero at all depths following the initial feedlot waste discharge in September (Figure 7). This condition prevailed until the period following the March waste discharge when the pond became highly supersaturated throughout with surface concentrations approaching 32 mg/1.

The March waste discharge from the feedlot produced a deviation from the usual pattern of dissolved oxygen concentrations within the receiving reservoir. Based on a comparison of dissolved oxygen profiles in the receiving reservoir following the discharge with profiles for the preceding year, the duration of this anomaly was about three months (Figure 8). The initial effect of this discharge was a decrease in dissolved oxygen concentrations from saturation to 0.0 mg/1 throughout the reservoir. One week later, at 2 p.m. on April 14, 1970, the dissolved oxygen levels had increased to a supersaturated level of 14.2 mg/1 at the surface and 3.2 mg/1 near the bottom. The next morning, just before first light at 4:14 a.m., there was 4 mg/1 at the surface decreasing to 3.7 mg/1 at 8 feet and 0.0 mg/1 near the bottom. A month later at midday, on May 19, 1970, the surface values were still above saturation. A thermocline had formed between 2 and 4 feet causing the dissolved oxygen to decrease to 2 mg/1 at 4 feet and 0.0 mg/1 near the bottom. On July 14, 1970, the dissolved oxygen curve was typical of the reservoir before the influence of waste discharge.

Pumped runoff from the feedlot for the period beginning in March contained from 2 to 4 times the amount of selected chemical constituents as for the period in October and as high as 20 times the amount for the remaining pumping periods (Table II). Average concentrations of measured influent chemical constituents to the receiving reservoir ranged from 2 to 210 times the average effluent concentrations. In general, chemical concentrations of the effluent from the control reservoir were either less than or about equal to concentrations of effluent from the receiving reservoir (Appendix Table I). Exceptions were total dissolved solids and COD, which were 6 and 1.5 times greater, respectively, from the control than from the receiving reservoir.

TABLE 1

AVERAGE NUMBER OF TOTAL COLIFORM, FECAL COLIFORM, AND FECAL STREPTOCOCCI PER 100/ml

| | Date | 8/12/69 | 10/29/69[a] | 12/2/69[a] | 2/25/70[b] | 4/9/70[a] | 5/20/70 | 7/15/70 |
|---|---|---|---|---|---|---|---|---|
| Farm Pond | Total Coliform | 21,000 | 780,000 | 61,000 | 35,000 | 3,600 | 14,000 | 36,000 |
| | Fecal Coliform | <100 | 340,000 | 19,000 | 6,400 | 3,600 | <100 | -- |
| | Fecal Streptococci | 690 | 650,000 | 41,000 | 1,300,000 | 51,000 | <100 | 330 |
| Control Reservoir | Total Coliform | 130 | 36,700 | 770 | 44,000 | 590 | 8,600 | 110 |
| | Fecal Coliform | <10-10 | 1,400 | 80 | 14,100 | 130 | <10-70 | 140 |
| | Fecal Streptococci | 20 | 450 | <10-10 | 193,000 | 1,450 | 3,000 | 30 |
| Receiving Reservoir | Total Coliform | <100-200 | 1,000 | <100 | 2,100 | 50 | <10-100 | 110 |
| | Fecal Coliform | <100 | 450 | 20 | 1,300 | 80 | < 10-20 | 160 |
| | Fecal Streptococci | 70 | 180 | 20 | 7,500 | 2,400 | 30 | 40 |

[a] Sample collections following pumping of feedlot runoff.

[b] Sample collections following rainfall with watershed runoff.

TABLE II

VOLUME OF FEEDLOT WASTE DISCHARGES TO THE FARM POND AND MASS OF SELECTED CHEMICAL CONSTITUENTS[a]

| Pumping Period | 9/29-10/4 | 10/15-10/25 | 11/10-11/12 | 3/26-4/7 |
|---|---|---|---|---|
| Volume | 4.6 | 17.4 | 2.2 | 32.5 |
| Total Alkalinity | 9,850 | --- | --- | --- |
| Total Solids | 48,500 | 112,574 | 20,208 | 282,880[b] |
| Total Suspended Solids | 20,525 | 54,111 | 11,616 | 139,230[b] |
| Total Dissolved Solids | 27,975 | 58,462 | 8,592 | 174,148[b] |
| Chloride | 3,788 | 14,663[b] | 1,950 | 27,404[b] |
| Total Organic Nitrogen | 788 | 2,365 | 620 | 5,525 |
| Nitrate | 138 | 9.5 | 29.3 | 26.5 |
| Ammonia | 625 | 1,939 | 277 | 5,967 |
| Ortho-Phosphate | 288 | -- | -- | -- |
| Total Phosphate | 366 | 1,977 | 285 | 3,288 |
| COD | 28,213 | 79,369 | 25,416 | 195,806 |
| $BOD_5$ | 6,613 | 15,940 | 6,576 | 57,460 |
| TOC | 8,613 | 27,671 | 6,180 | 58,344 |

[a] The unit for volume is acre-feet and the unit for mass is pounds.

[b] These volumes were computed rather than measured. Mean values for other pumping periods were used as a basis for computations.

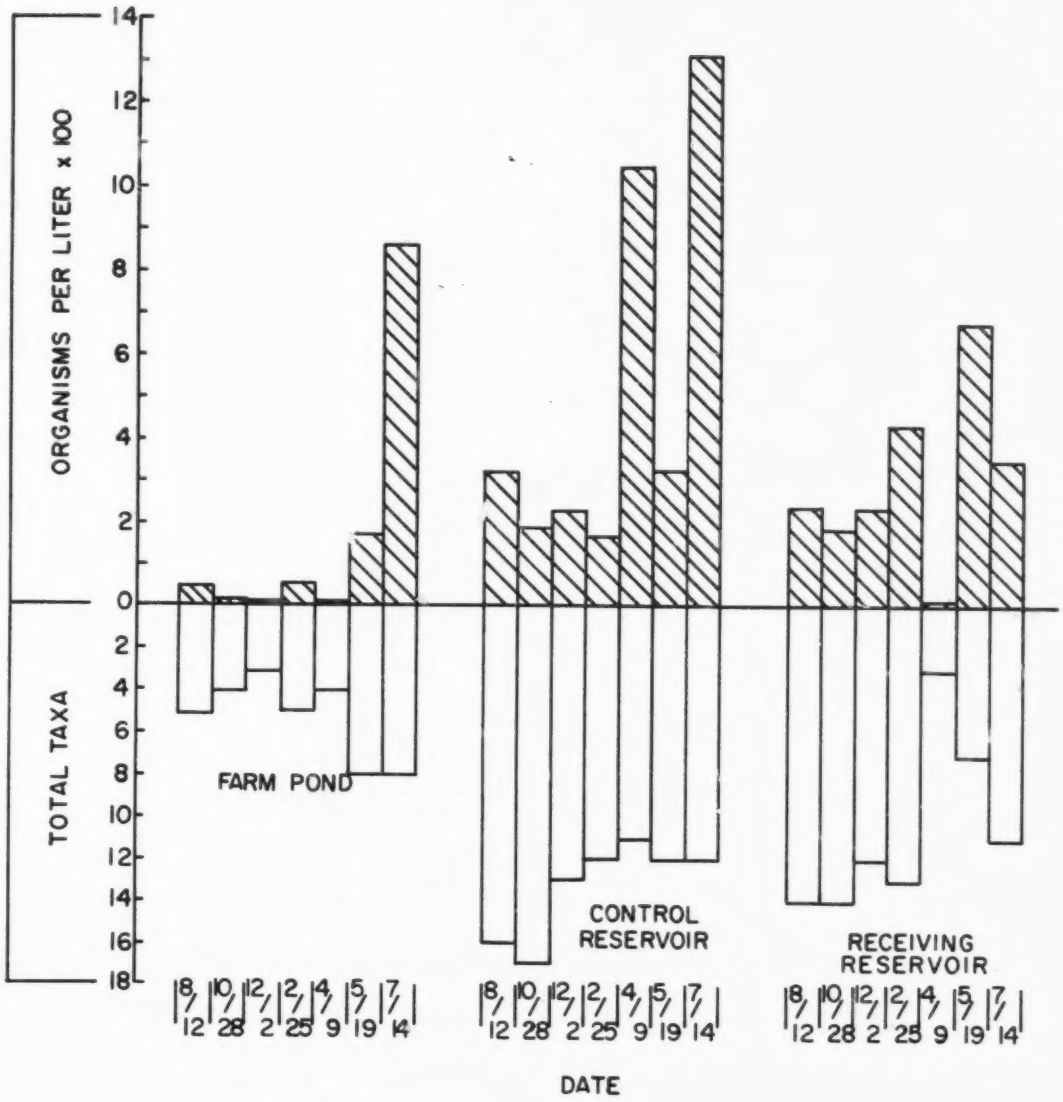



FIGURE 6. ZOOPLANKTON PER LITER, TOTAL ORGANISMS, AND NUMBER OF TAXA

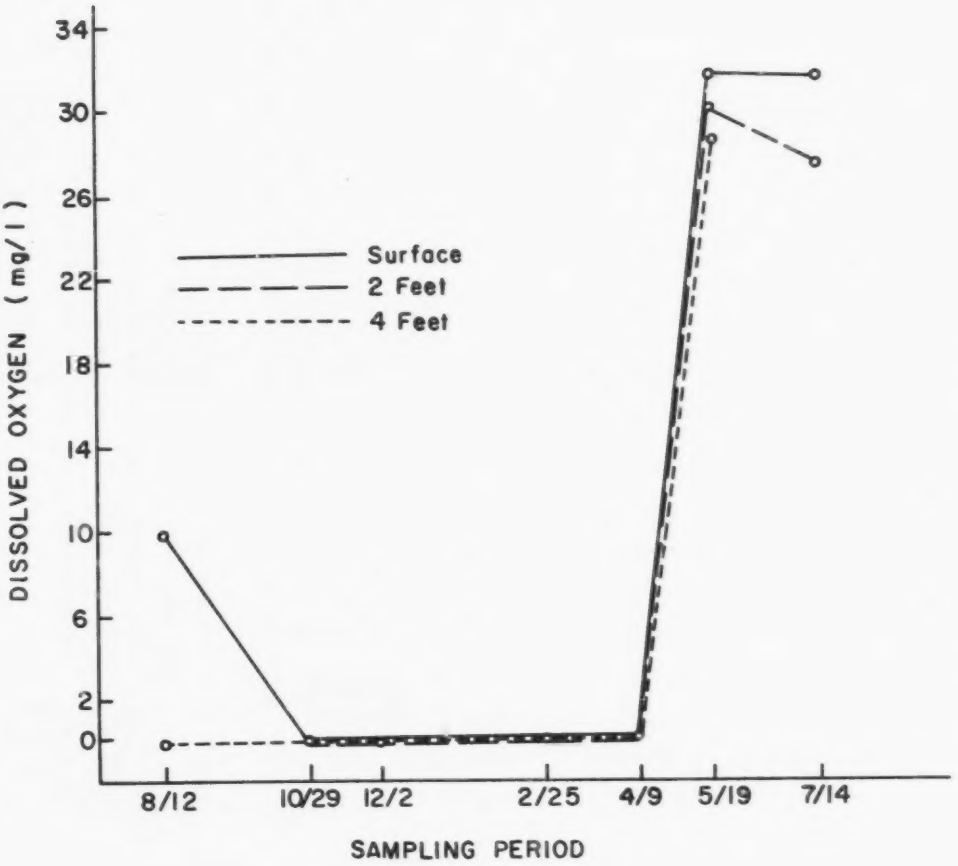



FIGURE 7. DISSOLVED OXYGEN CONCENTRATIONS IN THE FARM POND

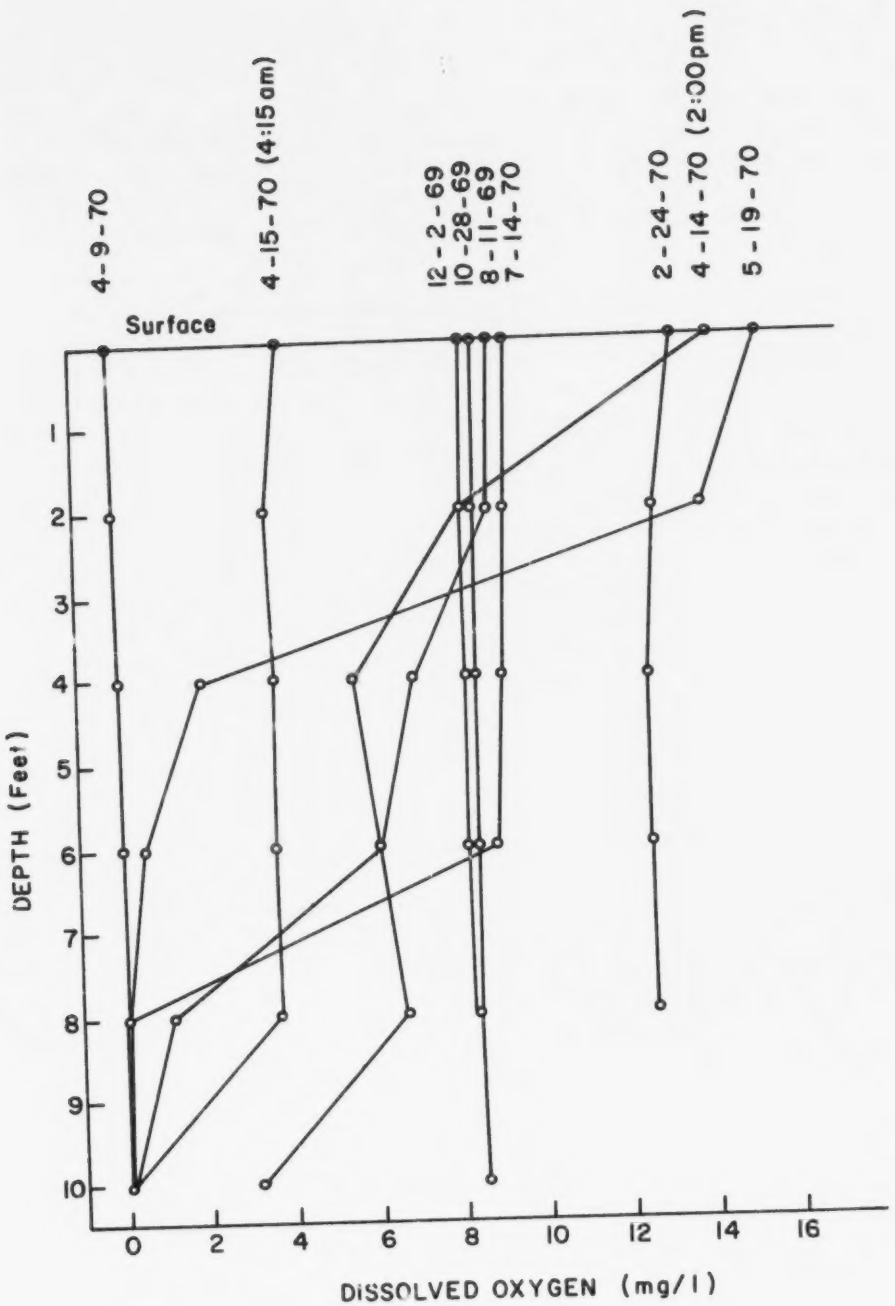



FIGURE 8. DISSOLVED OXYGEN PROFILES FOR THE RECEIVING RESERVOIR

Flow from the farm pond to the reservoir contained from 60 to 99 percent of the total mass of chemical constituents from the feedlot runoff for the pumping periods beginning in October and March; whereas, the average contribution for all chemical constituents was less than 45 percent for the pumping periods beginning in September and November (Tables III and IV.)

An increase in the concentration of total solids, chloride, total organic nitrogen, nitrate, ammonia, ortho-phosphate, and total phosphate in the farm pond and receiving reservoir followed each period of discharge of feedlot runoff (Appendix Tables II and III). Fluctuations in chemical and physical conditions of the control reservoir were seasonal and did not correlate with periods of feedlot waste discharge (Table V). Chemical constituents in the receiving reservoir, which displayed the greatest increases, were chloride, total suspended solids, and total organic nitrogen (Figures 9, 10, and 11). In addition, $BOD_5$ was 625 mg/l and ammonia was 50 mg/l in the farm pond and 87 mg/l and 7.5 mg/l, respectively, in the receiving reservoir during the waste discharge period beginning in March (Tables VI and VII). During this period, values for pH in the receiving reservoir ranged from 7.5 to 8.6. The limit of visibility in the receiving reservoir was reduced during the sampling periods immediately following the October and March waste discharges from the feedlot (Figure 12). Visibility in the control reservoir, however, fluctuated due to the effects of seasonal rainfall runoff.

Total rainfall for the study period was 35.8 inches (Figure 13). The largest rainfall amount was 4.15 inches in 9.5 hours on October 12, 1969. Rainfall of 2.0 and 2.5 inches occurred during the October and February sampling periods, respectively. The remaining sampling periods were preceded by 10 days or more when no rainfall occurred which was intense enough to cause runoff.

TABLE III

VOLUME OF FEEDLOT WASTE DISCHARGES TO THE RECEIVING RESERVOIR AND MASS OF SELECTED CHEMICAL CONSTITUENTS[a]

| Pumping Period | 9/29-10/4 | 10/15-10/25 | 11/10-11/12 | 3/26-4/7 |
|---|---|---|---|---|
| Volume | 1.6 | 18.1 | 2.3 | 33.7 |
| Total Alkalinity | 2,110 | 34,447[b] | 4,429[b] | 84,248[b] |
| Total Solids | 8,696 | 87,405 | 11,470 | 225,318 |
| Total Suspended Solids | 1,078 | 34,100 | 2,000 | 80,644 |
| Total Dissolved Solids | 7,616 | 53,540 | 9,470 | 144,674 |
| Chloride | 1,162 | 11,613[b] | 1,251 | 22,343 |
| Total Organic Nitrogen | 157 | 1,720 | 292 | 5,122 |
| Nitrate | .3 | 13 | 1.3 | 31 |
| Ammonia | 147 | 1,462 | 278 | 3,774 |
| Ortho Phosphate | 70 | 1,078[b] | 139[b] | 2,494 |
| Total Phosphate | 93 | 1,265 | 216 | 2,325 |
| COD | 8,131 | 58,861 | 8,678 | 119,568 |
| $BOD_5$ | 1,536 | 9,738 | 2,845 | 57,256 |
| TOC | 2,110 | 18,489 | 3,034 | 50,550 |

[a] The unit for volume is acre-feet and the unit for mass is pounds.

[b] These volumes were computed rather than measured. Mean values for other pumping periods were used as a basis for computations.

TABLE IV

PERCENTAGE OF TOTAL INPUT OF SELECTED CHEMICAL CONSTITUENTS TO RECEIVING RESERVOIR CONTRIBUTED BY FEEDLOT RUNOFF

| Pumping Period | 9/20-10/4 | 10/15-10/25 | 11/10-11/12 | 3/26-4/7 |
|---|---|---|---|---|
| Total Solids | 17 | 77 | 56 | 79 |
| Total Suspended Solids | 5 | 63 | 17 | 60 |
| Total Dissolved Solids | 27 | 91 | 100 | 83 |
| Chloride | 30 | 79 | 64 | 81 |
| Total Organic Nitrogen | 19 | 72 | 47 | 93 |
| Ammonia | 23 | 75 | 100 | 63 |
| Total Phosphate | 25 | 63 | 75 | 70 |
| COD | 28 | 74 | 34 | 61 |
| $BOD_5$ | 23 | 61 | 43 | 99 |
| TOC | 24 | 66 | 49 | 87 |

TABLE V

MEAN VALUES FOR STUDY PARAMETERS IN THE CONTROL RESERVOIR FOR EACH SAMPLING PERIOD [a]

| Date | 8-12 | 10-29 [b] | 12-2 [b] | 2-25 | 4-9 [b] | 5-20 | 7-15 |
|---|---|---|---|---|---|---|---|
| pH | 8.3 | 8.3 | 7.8 | 7.9 | 8.0 | 8.0 | 7.7 |
| Conductivity | 240 | 223 | 375 | 409 | 448 | 423 | 324 |
| Total Alkalinity | 110 | 105 | 171 | 181 | 244 | 224 | 168 |
| Total Solids | 197 | 245 | 367 | 330 | 327 | 258 | 209 |
| Total Suspended Solids | 50 | 79 | 122 | 104 | 53 | 33 | 26 |
| Total Dissolved Solids | 160 | 124 | 244 | 269 | 275 | 236 | 157 |
| Chloride | 8 | --- | 8 | 6 | 7 | 6 | 8 |
| Total Organic Nitrogen | 0.9 | 0.4 | 0.9 | 0.4 | 0.7 | 1.8 | 0.6 |
| Nitrate | 0.03 | 0.7 | 0.03 | 0.6 | 0.1 | 0.05 | 0.05 |
| Ammonia | 0.4 | 0.65 | 0.6 | 0.6 | 0.9 | --- | 0.6 |
| Ortho Phosphate | 0.03 | 0.02 | 0.3 | 0.1 | 0.03 | 0.03 | 0.07 |
| Total Phosphate | 0.15 | 0.6 | 0.3 | 0.3 | 0.2 | 0.06 | 0.08 |
| COD | --- | --- | --- | --- | --- | 28.8 | --- |
| $BOD_5$ | --- | --- | --- | --- | 4.8 | 3.4 | --- |
| TOC | --- | 13 | --- | --- | 5.9 | --- | --- |

[a] Conductivity reported as μmohs/cm, chemical concentrations are mg/l.

[b] Sample collections following pumping of feedlot runoff.

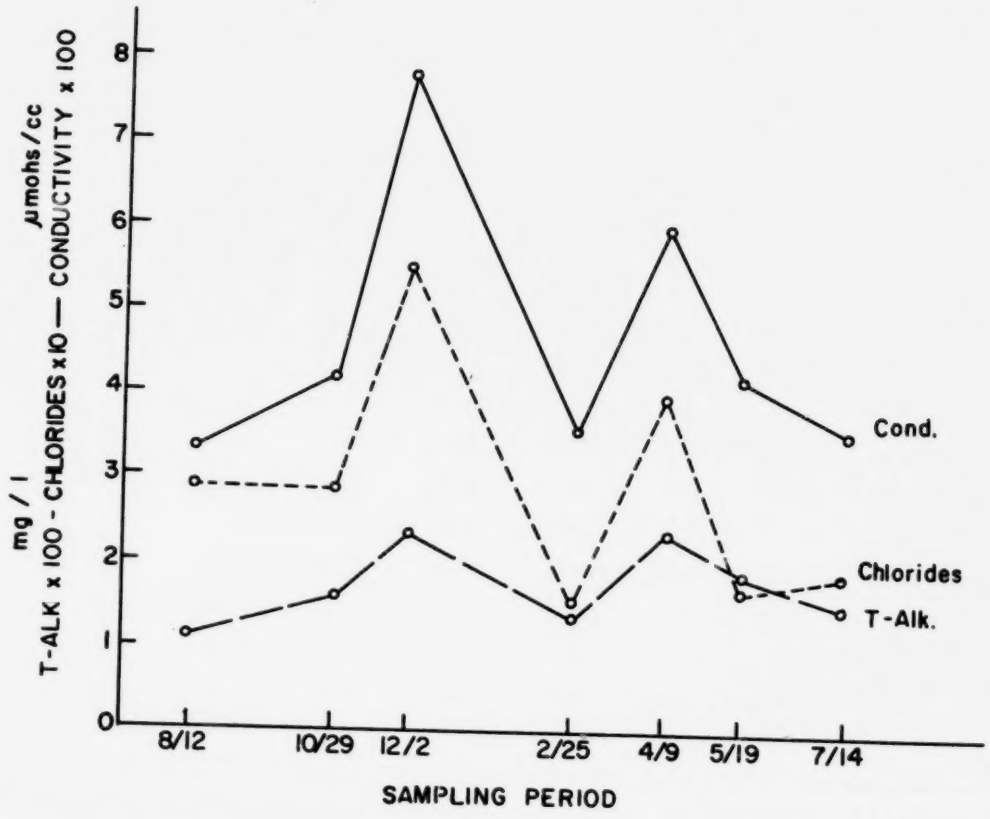



FIGURE 9. CHANGES IN CONDUCTIVITY, CHLORIDE, AND TOTAL ALKALINITY IN THE RECEIVING RESERVOIR

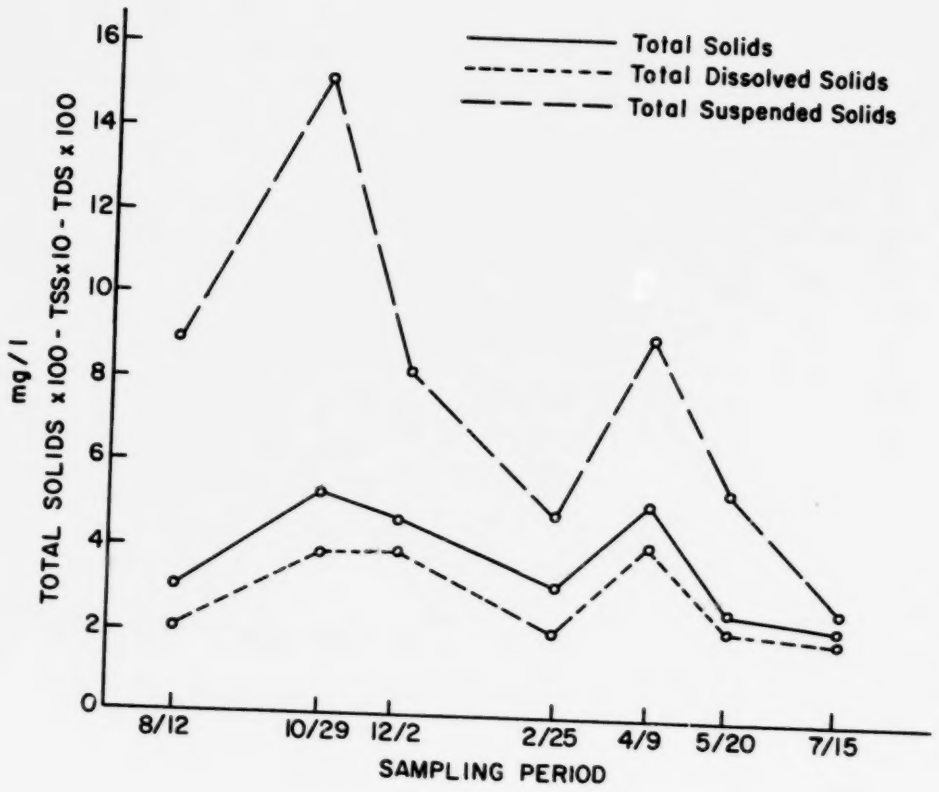



FIGURE 10. CHANGES IN TOTAL SOLIDS, TOTAL DISSOLVED SOLIDS, AND TOTAL SUSPENDED SOLIDS IN THE RECEIVING RESERVOIR

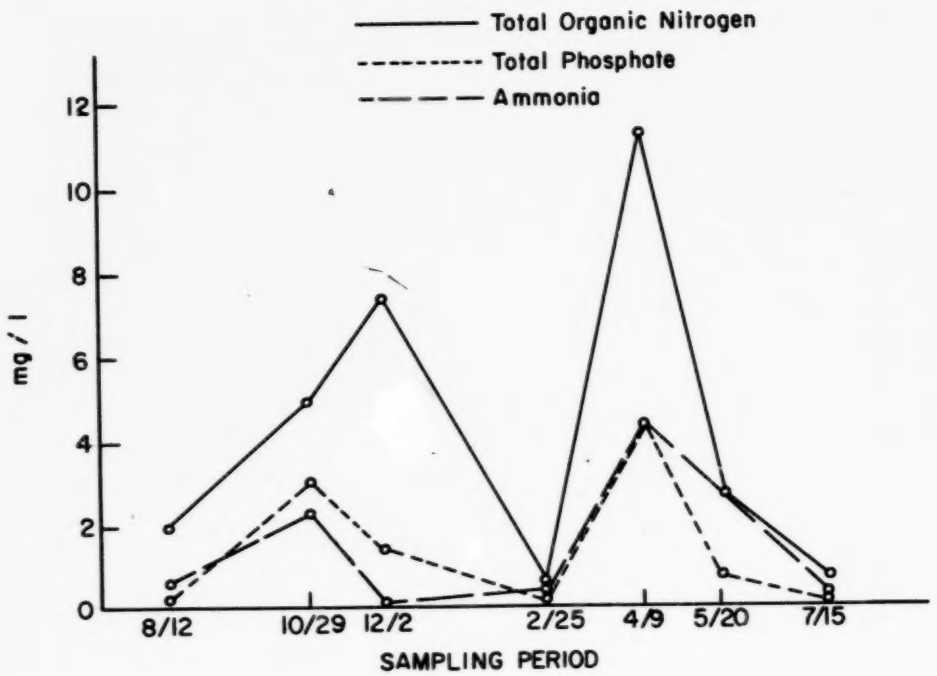



FIGURE 11. CHANGES IN AMMONIA, TOTAL ORGANIC NITROGEN, AND TOTAL PHOSPHATE IN THE RECEIVING RESERVOIR

TABLE VI

SUMMARY OF CHEMICAL AND PHYSICAL CONDITIONS IN THE CONTROL RESERVOIR AND THE RECEIVING RESERVOIR[a]

| | Receiving Reservoir | | | | | Control Reservoir | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N[b] | Mean | Min. Value | Max. Value | Value at Time of Fish Kill | N | Mean | Min. Value | Max. Value | Value at Time of Fish Kill |
| pH | 20 | 8.1 | 7.4 | 9.4 | 7.5 | 27 | 7.9 | 7.3 | 8.8 | 8.0 |
| Conductivity | 20 | 468 | 315 | 770 | 600 | 27 | 353 | 210 | 460 | 448 |
| Total Alkalinity | 20 | 181 | 110 | 296 | 260 | 26 | 173 | 84 | 244 | 244 |
| Total Solids | 20 | 370 | 220 | 576 | 521 | 27 | 262 | 179 | 371 | 327 |
| Total Suspended Solids | 20 | 74 | 25 | 155 | 85 | 25 | 50 | 10 | 150 | 53 |
| Total Dissolved Solids | 20 | 297 | 195 | 441 | 433 | 27 | 220 | 144 | 336 | 274 |
| Chloride | 19 | 29 | 16 | 55 | 41 | 24 | 7.1 | 6 | 8 | 6.8 |
| Total Organic Nitrogen | 20 | 4.4 | 0.05 | 12.5 | 11.5 | 27 | 0.87 | 0.3 | 2.5 | 0.7 |
| Nitrate | 20 | 0.1 | <0.03 | 0.4 | 0.03 | 27 | 0.12 | <0.05 | 0.6 | 0.11 |
| Ammonia | 17 | 1.7 | 0.05 | 7.5 | 7.5 | 23 | 0.53 | <0.05 | 1.4 | 0.9 |
| Ortho Phosphate | 20 | 0.87 | 0.02 | 3.2 | 2.9 | 27 | 0.09 | <0.02 | 0.72 | 0.034 |
| Total Phosphate | 19 | 1.46 | 0.19 | 4.5 | 4.4 | 27 | 0.22 | 0.011 | 1.15 | 0.175 |
| COD | 3 | 61 | 58 | 66 | --- | 4 | 29 | 27 | 31 | --- |
| $BOD_5$ | 6 | 46 | 9.5 | 113 | 87 | 8 | 4.1 | 2.2 | 7 | 4.75 |
| TOC | 5 | 53 | 47 | 64 | 56 | 7 | 9.8 | 7.5 | 14 | 8 |

[a]Conductivity reported as μmohs/cm, chemical concentrations are mg/l.

[b]Number of determinations.

TABLE VII

SUMMARY OF CHEMICAL AND PHYSICAL CONDITIONS IN THE FARM POND[a]

| | N[b] | Mean | Min. Value | Max. Value | Value at Time of Fish Kill |
|---|---|---|---|---|---|
| pH | 7 | 8.7 | 7.6 | 9.7 | 7.6 |
| Conductivity | 7 | 2,036 | 330 | 2,600 | 2,300 |
| Total Alkalinity | 7 | 457 | 124 | 1,020 | 920 |
| Total Solids | 7 | 1,214 | 273 | 2,459 | 2,459 |
| Total Suspended Solids | 7 | 264 | 38 | 880 | 880 |
| Total Dissolved Solids | 7 | 978 | 200 | 1,966 | 1,579 |
| Chloride | 6 | 113 | 13 | 244 | 244 |
| Total Organic Nitrogen | 7 | 35.3 | 2.35 | 90 | 90 |
| Nitrate | 7 | 8.5 | <.03 | 56 | 56 |
| Ammonia | 7 | 16.3 | .5 | 50 | 50 |
| Ortho Phosphate | 6 | 16 | .345 | 34.5 | 27.2 |
| Total Phosphate | 7 | 19 | .675 | 40 | 31.5 |
| COD | 3 | 708 | 90 | 1,816 | --- |
| $BOD_5$ | 2 | 317.5 | 10 | 625 | 625 |
| TOC | 4 | 364 | 16 | 840 | 840 |

[a]Conductivity reported as µmohs/cm, chemical concentration are mg/l.

[b]Number of determinations.

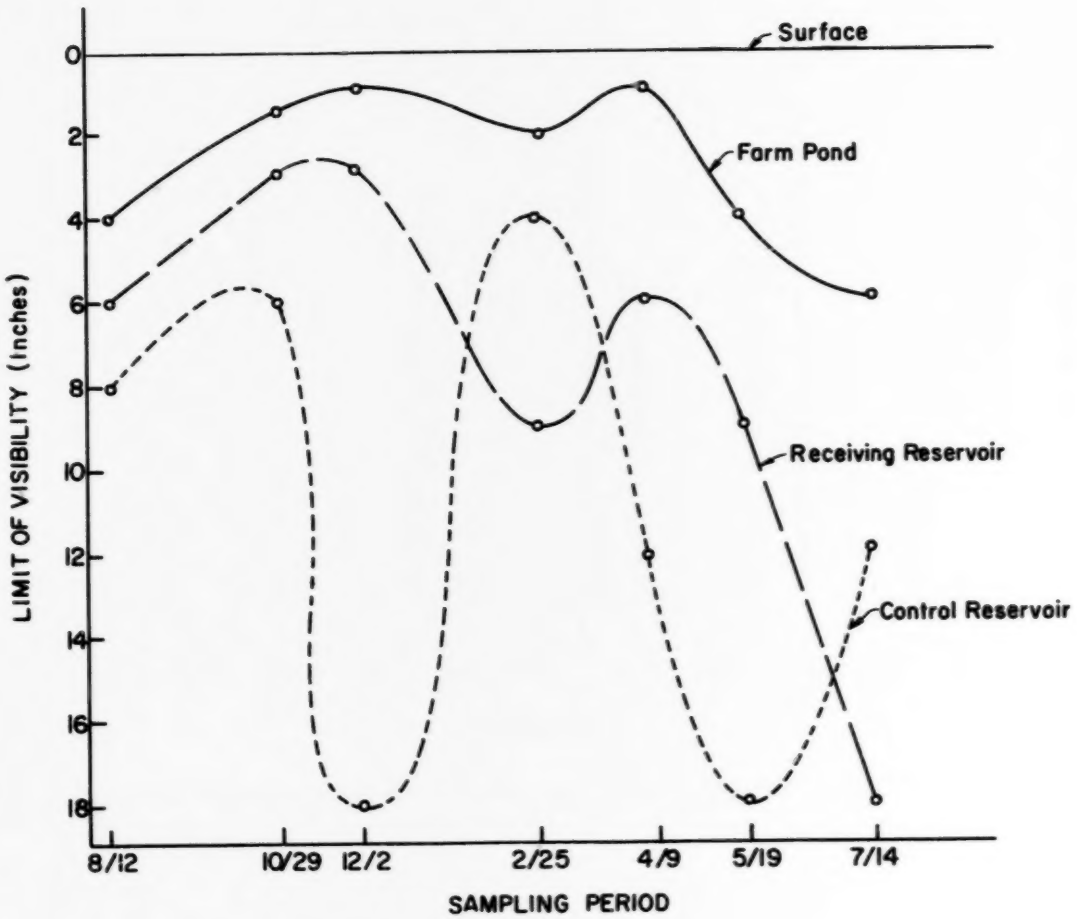
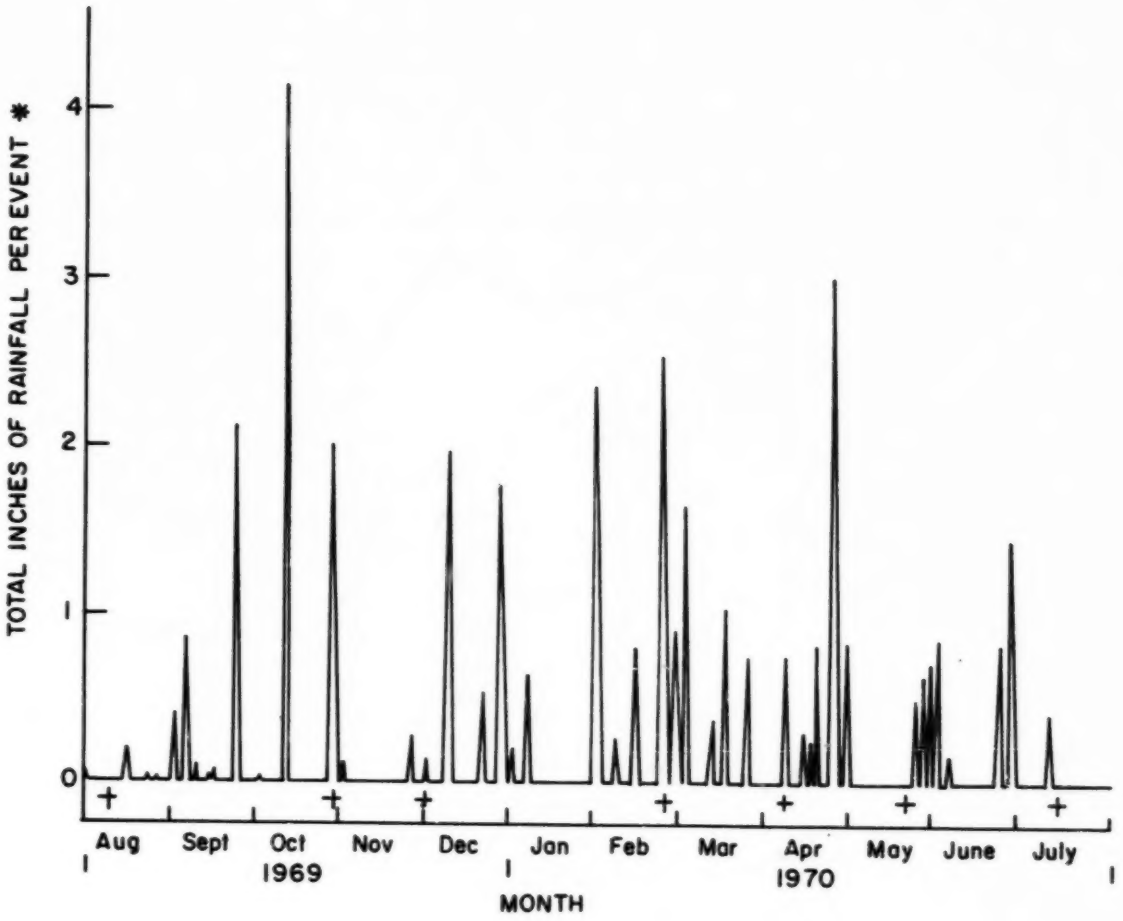



FIGURE 12. LIMIT OF VISIBILITY IN THE FARM POND, CONTROL RESERVOIR, AND RECEIVING RESERVOIR




* All rainfall not separated by more than 24 hours was totaled to equal one event.

+ Sample collections

FIGURE 13. SAMPLE COLLECTIONS AND RECORD OF RAINFALL FOR THE STUDY PERIOD

## SECTION VI

## DISCUSSION

Examination of chemical and physical conditions in the receiving reservoir and the control reservoir revealed differences in several parameters. Differences are greater in values obtained at the time of the fish kill than in overall mean values. Effects due to feedlot runoff are higher conductivity and oxygen demand and greater concentration of solids, chloride, nitrogen, and phosphorus. Turbidity was influenced by suspended solids concentrations and phytoplankton populations. During the 4-month period when no feedlot wastes were discharged to the receiving reservoir, the limit of visibility increased becoming greater than that of the control reservoir. However, in April, following discharge of feedlot wastes into the receiving reservoir, the limit of visibility again decreased to less than that of the control reservoir. Changes which occurred in the community structure of aquatic organisms are attributable to chemical and physical conditions following the input of feedlot wastes.

Aquatic organisms react to changes in the conditions of their environment according to the tolerance of individual species. Addition of highly organic substances or pollutants often reduces the quantity of species and increases the total number of organisms in the aquatic community. Large population reductions or elimination of entire elements of the biota are caused by excessive additions of pollutants which create toxic conditions to existing biological forms. The degree of toxicity is dependent upon the volumetric ratio of waste discharge to receiving water, concentration of pollutants, assimilative capacity of the receiving water, and seasonal variations. The response of aquatic populations in the farm pond and receiving reservoir was characteristic of those receiving both organic wastes and toxic substances.

The most dramatic change in the aquatic community was observed between April 7 and 11, 1970, when an estimated 90 percent of the game fish in the receiving reservoir died. This fish kill followed the March discharge of feedlot runoff to the reservoir having high oxygen demand and high concentrations of solids, ammonia, nitrate, and phosphate. Proportions of game and rough fish are consistent with a kill caused by dissolved oxygen stress. Low dissolved oxygen concentration, resulting from discharged oxygen-demanding organic pollutants to the reservoir, was the primary cause of the fish kill. The ability of hemoglobin to combine with oxygen is decreased when ammonia concentrations exceed 1.0 mg/l, and concentrations of 2.5 mg/l may be harmful to fish in water with a pH range between 7.4 and 8.5.[7,8] The ammonia concnetration in the receiving reservoir during the fish kill was 7.5 mg/l, and the pH ranged from 7.5 to 8.6 Thus, the discharge of waste containing high ammonia concentrations, which inhibited the oxygen absorption capabilities of the hemoglobin, contributed to the suffocation of the fish.

The assimilative capacity of the receiving reservoir for oxygen-demanding organic pollutants was sufficient to prevent the suffocation of fishes tolerant of prolonged periods of low dissolved oxygen concentrations. A phytoplanktonic bloom which began in the littoral zone and gradually spread to the center of the receiving reservoir increased the daytime dissolved oxygen concentration of the reservoir. Within seven days, diurnal dissolved oxygen concentration was again sufficient to sustain both game and rough fish. Three months following the fish kill, dissolved oxygen levels had returned to typical seasonal levels.

Reactions of invertebrate and plankton populations to changes caused by the introduction of feedlot wastes to the farm pond and receiving reservoir were less obvious than those of the fish. However, detailed examination of the community structure of these organisms revealed significant population changes following major waste discharge periods. The greatest changes occurred in the farm pond where the volume of pumped feedlot runoff was sufficient to replace the water in the pond. During the October and April sampling periods, waste discharges which caused decreases in populations of benthos, zooplankton, and phytoplankton appeared to be toxic. Dissolved oxygen was eliminated from the farm pond following the October discharge and was not recovered until after the March discharge. Population levels of benthos and zooplankton remained very low during the period of zero dissolved oxygen concentration. As dissolved oxygen concentrations in the farm pond increased, the number of benthic organisms and zooplankters increased to population levels indicative of highly enriched waters.

Algae, which thrive on high nitrate concentrations, appear to be harmed or inhibited when nitrogen is in the form of ammonia.[7] Ammonia concentrations which resulted from drainage of highly concentrated feedlot runoff to the farm pond contributed to the suppression of algal populations during early April.

Runoff discharge to the receiving reservoir produced changes in the benthos and zooplankton which were similar to those observed in the farm pond. However, the ratio of runoff discharged from the feedlot to the receiving reservoir was about 1:4 for both the October and March pumping periods. Thus, as expected, the increased assimilative capacity due to greater dilution in the receiving reservoir prevented biological changes as severe as those observed in the farm pond. An exception was the severity of the March discharge on the zooplankton as observed by an immediate population reduction. Intolerant benthic forms diminished and tolerant forms remained immediately following discharge periods in which large volumes of feedlot runoff were transferred to the receiving reservoir, shifting the population rather than greatly reducing the total number of organisms. Population changes immediately after discharge were followed by a period in which both the benthos and zooplankton exhibited increases in the total number of organisms to levels significantly greater than those prior to receiving feedlot waste materials.

Phytoplankton populations increased more rapidly than those of the benthos and zooplankton following major discharges of feedlot wastewater to the receiving reservoir. This was due to an abundance of available nutrients as well as the capability of photosynthetic phytoplankters to use the carbon dioxide by-product of oxidation of organic pollutants in the feedlot wastes. The increase of phytoplankton to bloom proportions, along with natural forces causing mixing, aided the assimilative ability of the receiving reservoir immediately following the fish kill.

Algal blooms exhibit a beneficial effect on recovery from low dissolved oxygen concentrations during periods of high light intensity, but create additional oxygen demand due to respiration during the nighttime. The profile measured at 2 p.m. on April 14 reflected the increase in dissolved oxygen caused by algal production. However, by early morning of the following day, oxygen production had ceased, and consuming materials including algae had significantly depressed dissolved oxygen concentrations as demonstrated by the 4:15 a.m. profile (Figure 8).

An absolute minimum amount of feedlot waste effluent that will damage aquatic life in the receiving reservoir was not established. Other environmental variables such as pollutant concentrations, wind, light intensity, and temperature are important parts of a complex combination of factors influencing biological populations. The volumetric ratio of feedlot runoff to the water of the receiving reservoir was the same for both major pumping periods. However, the concentration of pollutants in the pumped feedlot runoff was two to four times greater in March than in October, creating more extensive damage to the environment of the receiving reservoir. Signs of recovery were apparent in the receiving reservoir within a few days following pumping. At this time, dissolved oxygen concentrations were sufficient to support fish and other aquatic life.

Examination of microbiological data indicated that samples collected after periods of extensive rainfall maintained counts of much greater magnitude than samples collected after feedlot waste discharges. This is due to sufficient retention time of the waste in holding ponds allowing for die-off of a large percentage of organisms.

SECTION VII

## ACKNOWLEDGMENTS

The cooperation and assistance of the personnel of D. H. Byrd Enterprises of Dallas, Texas, owners of the feedlot, small farm pond, and control reservoir used in this study are gratefully acknowledged. The cooperation of Mr. E. K. Norton, Jr., who allowed access to the waste-receiving reservoir used in this study, is greatly appreciated.

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## SECTION VIII

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SECTION IX

# APPENDICES


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2. Total Number of Taxa of Phytoplankters and Number of Organisms Per Milliliter. . . . . 53


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TABLE I

SUMMARY OF VOLUME OF WATER DISCHARGED AND TOTAL WEIGHT AND AVERAGE CONCENTRATIONS FOR EACH CHEMICAL CONSTITUENT

| | Station | 1 | 2 | 3 | P-4 | T-4 |
|---|---|---|---|---|---|---|
| | Volume | 750.5 | 1,483 | 56.7 | 55.7 | 133 |
| Total Alkalinity | Concentration | 502 | 552 | -- | 2,249 | 1,387 |
| | Total Weight | 376,999 | 818,496 | -- | 125,270 | 184,471 |
| Total Solids | Concentration | 923 | 914 | 8,186 | 5,976 | 3,834 |
| | Total Weight | 692,407 | 1,354,752 | 464,162 | 332,889 | 509,922 |
| Total Suspended Solids | Concentration | 136 | 244 | 3,977 | 2,115 | 1,185 |
| | Total Weight | 101,751 | 362,880 | 225,482 | 117,822 | 157,605 |
| Total Dissolved Solids | Concentration | 104 | 641 | 4,746 | 3,865 | 2,705 |
| | Total Weight | 78,180 | 951,552 | 269,117 | 215,300 | 359,765 |
| Chloride | Concentration | 72 | 12 | 843 | 653 | 285 |
| | Total Weight | 53,746 | 17,902 | 47,805 | 36,369 | 37,905 |
| Total Organic Nitrogen | Concentration | 11 | 2.2 | 164 | 131 | 72 |
| | Total Weight | 8,484 | 3,226 | 9,258 | 7,291 | 9,576 |
| Nitrate | Concentration | 1.1 | 0.7 | 3.6 | 0.8 | 3.2 |
| | Total Weight | 798 | 968 | 203 | 45 | 423 |
| Ammonia | Concentration | 10 | 1.5 | 155 | 102 | 62 |
| | Total Weight | 7,678 | 2,177 | 8,808 | 5,661 | 8,246 |
| Ortho Phosphate | Concentration | 2.6 | 0.2 | --- | 68 | 42 |
| | Total Weight | 1,937 | 323 | --- | 3,781 | 5,586 |
| Total Phosphate | Concentration | 3.5 | 0.6 | 104 | 70 | 45 |
| | Total Weight | 2,601 | 447 | 5,916 | 3,899 | 5,985 |
| Chemical Oxygen Demand | Concentration | 170 | 245 | 5,799 | 3,505 | 2,371 |
| | Total Weight | 127,552 | 362,880 | 328,804 | 195,238 | 315,345 |
| Biochemical Oxygen Demand | Concentration | 98 | 14 | 1,511 | 1,281 | 886 |
| | Total Weight | 73,872 | 20,160 | 85,689 | 71,375 | 117,838 |
| Total Organic Carbon | Concentration | 128 | 38 | 1,778 | 1,332 | 726 |
| | Total Weight | 26,146 | 56,448 | 100,808 | 74,192 | 96,558 |

NOTE: Station 1 represents total discharge through drawdown of reservoir receiving feedlot wastes. Station 2 represents total discharge through drawdown of control reservoir. Station 3 represents pumped feedlot waste influent to Farm Pond. Station P-4 represents effluents from Farm Pond during pumping. Station T-4 represents total effluent from Farm Pond. Units for volume, concentration, and total weight are acre-feet, pounds per acre foot, and pounds respectively.



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TABLE II

MEAN VALUES FOR STUDY PARAMETERS IN THE FARM POND FOR EACH SAMPLING PERIOD [a]

| Date | 8-12 | 10-29[b] | 12-2[b] | 2-25 | 4-9[b] | 5-20 | 7-15 |
|---|---|---|---|---|---|---|---|
| pH | 8.4 | 7.8 | 9.2 | 8.7 | 7.6 | 9.7 | 9.3 |
| Conductivity | 1030 | 1650 | 2600 | 330 | 2300 | 340 | 340 |
| Total Alkalinity | 283 | 580 | 1020 | 136 | 920 | 138 | 124 |
| Total Solids | 947 | 2017 | 2126 | 392 | 2459 | 282 | 273 |
| Total Suspended Solids | 107 | 316 | 260 | 192 | 880 | 58 | 38 |
| Total Dissolved Solids | 840 | 1701 | 1966 | 200 | 1579 | 224 | 335 |
| Chloride | 141 | -- | 230 | 13 | 244 | 24 | 24 |
| Total Organic Nitrogen | 13.6 | 42.5 | 87 | 0.9 | 90 | 3.5 | 2.4 |
| Nitrate | <0.03 | 0.14 | 0.1 | 2.8 | 56 | 0.36 | <0.05 |
| Ammonia | 7.3 | 45 | 10 | 0.9 | 50 | -- | 0.35 |
| Ortho Phosphate | 3.3 | 30 | 34.5 | -- | 27.2 | 0.46 | 0.345 |
| Total Phosphate | 5.4 | 35.3 | 40 | 17.8 | 31.5 | 1.1 | 0.8 |
| COD | -- | 1816 | -- | 90 | -- | 2.7 | -- |
| $BOD_5$ | -- | -- | -- | -- | 625 | 10 | -- |
| TOC | -- | 580 | 20 | 16 | 840 | -- | -- |

[a] Conductivity reported as μmons/cm, chemical concentrations are mg/l.

[b] Sample collections following pumping of feedlot runoff.

TABLE III

MEAN VALUES FOR STUDY PARAMETERS IN RECEIVING RESERVOIR FOR EACH SAMPLING PERIOD[a]

| Date | 8-12 | 10-29 | 12-2 | 2-25 | 4-9 | 5-20 | 7-15 |
|---|---|---|---|---|---|---|---|
| pH | 7.9 | 7.9 | 8.0 | 8.48 | 7.56 | 8.8 | 8.0 |
| Conductivity[b] | 332 | 425 | 773 | 353 | 600 | 420 | 357 |
| Total Alkalinity | 117 | 160 | 240 | 137 | 260 | 192 | 153 |
| Total Solids | 304 | 546 | 492 | 262 | 523 | 284 | 240 |
| Total Suspended Solids | 85 | 152 | 83 | 48 | 92 | 55 | 27 |
| Total Dissolved Solids | 219 | 395 | 409 | 214 | 432 | 229 | 213 |
| Chloride | 29 | 29 | 55 | 16 | 41 | 17 | 19 |
| Total Organic Nitorgen | 2 | 5 | 7.4 | 0.67 | 11.3 | 2.7 | 0.62 |
| Nitrate | <0.03 | 0.07 | 0.39 | 0.2 | 0.02 | <0.05 | <0.05 |
| Ammonia | 0.67 | 2.6 | 0.26 | 0.53 | 4.3 | -- | 0.55 |
| Ortho Phosphate | 0.04 | 1.19 | 1.31 | 1.1 | 2.8 | 0.53 | 0.152 |
| Total Phosphate | 0.25 | 3.1 | 1.62 | 0.26 | 4.4 | 0.86 | 0.22 |
| COD | -- | -- | -- | -- | -- | 61 | -- |
| $BOD_5$ | -- | -- | -- | -- | 82 | 9.8 | -- |
| TOC | -- | 48 | -- | -- | 56 | -- | -- |

[a] Conductivity reported on μmohs/cm, chemical concentration are mg/l.

[b] Sample Collections following pumping of feedlot runoff.

TABLE IV

SUMMARY OF BENTHIC MICROINVERTEBRATES COLLECTED PER SQUARE METER

| Taxa | Small Farm Pond | Receiving Reservoir | Control Reservoir |
|---|---|---|---|
| Ephemeroptera - mayflies | | | |
| *Hexogenia* sp. | 0 | 0 | A |
| Trichoptera - caddisflies | | | |
| *Hesperophylax* sp. | 0 | A | 0 |
| *Limnephilus* sp. | 0 | 0 | A |
| *Ochrotrichia* sp. | 0 | 0 | A |
| *Polycentropus* sp. | A | 0 | A |
| *Triaenodes* sp. | 0 | B | 0 |
| Coleoptera - beetles | | | |
| *Hydrophilus* sp. | B | 0 | A |
| *Hydroporus* sp. | A | 0 | 0 |
| Diptera - true flies | | | |
| *Alluaudommyia* sp. | 0 | 0 | A |
| *Calopsectra* sp. | A | A | B |
| *Cardiocladius* sp. | A | A | B |
| *Chaoborus* sp. | D | D | E |
| *Chironomus* sp. | E | D | D |
| *Coelotanypus* sp. | B | D | D |
| *Dolichopus* sp. | 0 | 0 | A |
| *Glyptotendipes* sp. | B | C | D |
| *Muscid* sp. | 0 | 0 | A |
| *Palpomyia* sp. | B | C | C |
| *Pentaneura* sp. | 0 | B | C |
| *Probezzia* sp. | A | B | C |
| *Procladius* sp. | D | D | E |
| *Pseudochironomus* sp. | 0 | B | 0 |
| *Tanypus* sp. | C | E | D |
| Hirudiniea - leeches | | | |
| *Placobdella* sp. | 0 | 0 | A |
| Pelecypoda - clams | | | |
| *Musculium* sp. | 0 | A | 0 |
| Gastropoda - snails | | | |
| *Physa* sp. | A | 0 | 0 |
| Nematoda - roundworms | | | |
| *Alaimus* sp. | 0 | B | B |
| *Cephalobus* sp. | 0 | A | A |
| *Diplogaster* sp. | A | D | B |

TABLE IV--Continued

| | Small Farm Pond | Receiving Reservoir | Control Reservoir |
|---|---|---|---|
| *Dolichodorus* sp. | 0 | A | 0 |
| *Dorylaimus* sp. | 0 | E | B |
| *Ironus* sp. | 0 | 0 | A |
| Hydracarina - watermites | | | |
| *Diplodontus* sp. | 0 | A | A |
| *Eylais* sp. | 0 | A | A |
| *Hydryphantes* sp. | 0 | B | B |
| *Lebertia* sp. | 0 | A | 0 |
| *Mideopsis* sp. | 0 | B | A |
| *Neumania* sp. | 0 | A | A |
| *Oxus* sp. | B | B | B |
| Oligochaeta - segmented worms | | | |
| *Dero* sp. | A | D | 0 |
| *Limnodrilus* sp. | D | D | E |
| *Naidium* sp. | 0 | A | B |
| *Nais* sp. | B | E | D |
| *Stylaria* sp. | 0 | 0 | A |

NOTE: 0 = Not collected
A = 1-5/$m^2$
B = 6-50/$m^2$
C = 51-100/$m^2$
D = 100-500/$m^2$
E = 500+ /$m^2$

TABLE V

SUMMARY OF ZOOPLANKTON COLLECTED PER LITER[a]

| | Small Farm Pond | Receiving Reservoir | Control Reservoir |
|---|---|---|---|
| Rotifera | | | |
| *Asplanchna* sp. | 1 | 6 | 3 |
| *Brachious* sp. | 2 | 5 | 4 |
| *Filinia* sp. | 5 | 7 | 5 |
| *Keratella* sp. | 1 | 7 | 5 |
| *Polyarthra* sp. | 3 | 2 | 3 |
| *Synchaeta* sp. | 0 | 2 | 2 |
| *Philodina* sp. | 0 | 2 | 2 |
| *Trichocera* sp. | 0 | 2 | 2 |
| Copopoda | | | |
| Nauplius larvae | 3 | 7 | 6 |
| *Ectocyclops* sp. | 2 | 8 | 7 |
| *Orthocyclops* sp. | 4 | 7 | 6 |
| Cladocera | | | |
| *Alonopsis* sp. | 0 | 4 | 4 |
| *Bosmina* sp. | 4 | 7 | 7 |
| *Ceriodaphnia* sp. | 1 | 7 | 4 |
| *Daphnia* sp. | 4 | 6 | 4 |
| *Diaphanosoma* sp. | 0 | 4 | 1 |
| *Sida* sp. | 2 | 2 | 3 |
| *Simocephalus* sp. | 0 | 3 | 2 |
| Ostracoda | | | |
| *Cypridopsis* sp. | 4 | 6 | 6 |

[a] Numbers indicate occurrence of a possible seven.

TABLE VI

SUMMARY OF PHYTOPLANKTON COLLECTED PER MILLILITER

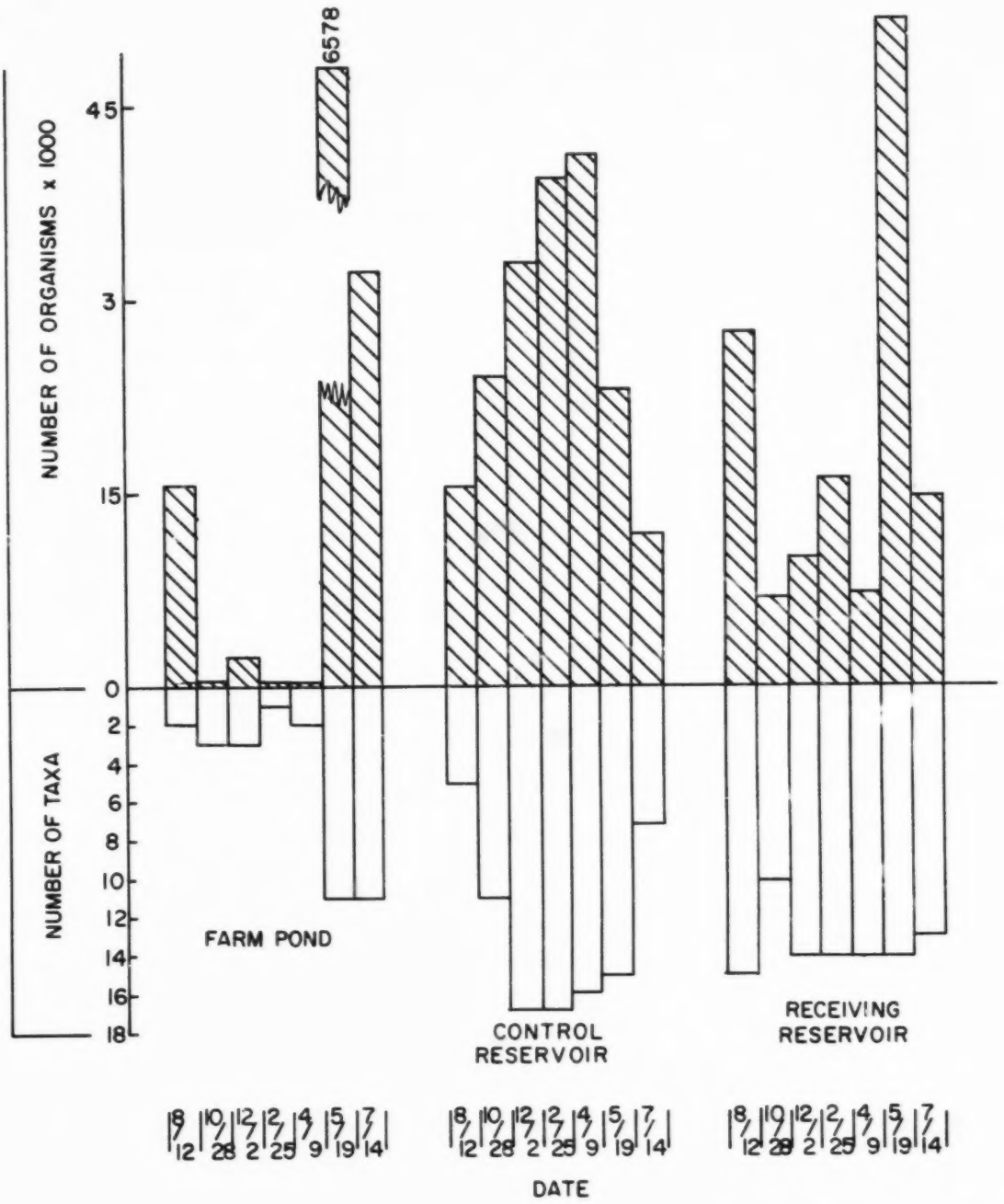
| | Small Farm Pond | Receiving Reservoir | Control Reservoir |
|---|---|---|---|
| Chlorophyta - green | | | |
| Actinastrum | B | B | 0 |
| Ankistrodesmus | D | E | D |
| Arthrodesmus | 0 | 0 | A |
| Carteria | D | D | C |
| Cerasterias | 0 | 0 | A |
| Chlamydomonas | D | E | E |
| Chlorella | E | E | E |
| Closterium | D | B | A |
| Closteriopsis | 0 | C | C |
| Coelastrum | 0 | D | C |
| Cosmarium | 0 | A | C |
| Crucigenia | A | D | C |
| Desmatractum | 0 | 0 | A |
| Dictyoshaerium | 0 | A | B |
| Dimorphococcus | 0 | 0 | B |
| Dispora | 0 | C | A |
| Dysmorphococcus | D | C | 0 |
| Elakatothrix | 0 | A | A |
| Eudorina | D | B | 0 |
| Gloeocystis | 0 | 0 | B |
| Golenkinia | C | B | B |
| Gonium | C | A | 0 |
| Hormidium | 0 | B | 0 |
| Kirchneriella | 0 | 0 | A |
| Lobomonas | D | D | 0 |
| Micractinium | D | C | A |
| Mougeotia | B | C | D |
| Microspora | 0 | 0 | B |
| Oocystis | B | D | D |
| Ourococcus | D | A | 0 |
| Pandorina | 0 | A | 0 |
| Pamella | D | C | B |
| Pamellococcus | D | D | 0 |
| Pleurotaenium | 0 | A | B |
| Pachycladon | 0 | 0 | A |
| Pediastrum | B | C | B |
| Pedinomonas | C | 0 | 0 |
| Plankophaeria | 0 | A | 0 |
| Platymonas | D | B | A |
| Pyrobotrys | D | 0 | 0 |
| Pyramimonas | 0 | 0 | A |
| Scenedesmus | D | D | B |

TABLE VI--Continued

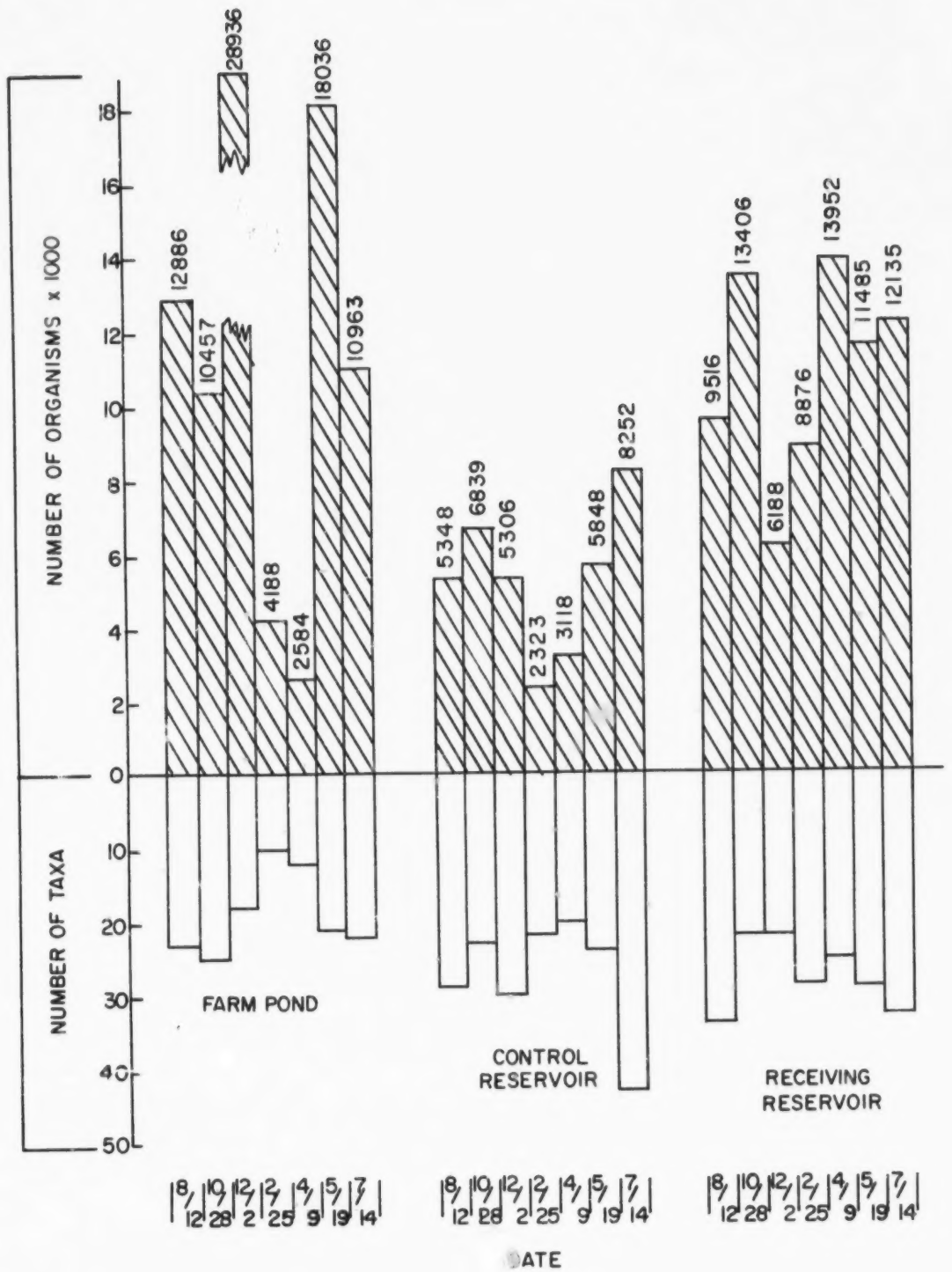
| | Small Farm Pond | Receiving Reservoir | Control Reservoir |
|---|---|---|---|
| Schroederia | A | 0 | C |
| Selenastrum | D | B | A |
| Staurastrum | 0 | B | A |
| Spirotaenia | 0 | A | 0 |
| Tetraedron | 0 | A | A |
| Treubaria | 0 | 0 | A |
| Trochiscia | 0 | D | C |
| Tetrallentos | E | 0 | 0 |
| Ulothrix | A | 0 | 0 |
| Volvox | D | B | B |
| Westella | 0 | B | B |
| Chrysophyta - yellow brown | | | |
| Botryococcus | D | D | D |
| Caloneis | 0 | A | 0 |
| Centronella | 0 | A | 0 |
| Chrysopyxis | 0 | 0 | A |
| Cocconeis | C | D | B |
| Cymbella | 0 | A | A |
| Cyclotella | D | D | D |
| Fragilaria | C | A | A |
| Frustulia | 0 | A | A |
| Gyrosigma | 0 | A | 0 |
| Hantzchia | 0 | 0 | A |
| Lagynion | 0 | A | 0 |
| Mastigoloia | B | B | B |
| Meridon | 0 | 0 | A |
| Melosira | B | D | B |
| Mallomonas | B | D | B |
| Navicula | B | B | B |
| Nitzchia | C | D | B |
| Pinnularia | 0 | A | A |
| Scoliopleura | 0 | A | 0 |
| Stephanodiscus | C | D | C |
| Synedra | A | B | C |
| Synura | E | A | 0 |
| Cyanophyta - blue green | | | |
| Anacystis | B | C | B |
| Aphanizomenon | A | D | D |
| Arthrospira | B | 0 | 0 |
| Calothrix | C | 0 | 0 |
| Chroococcus | 0 | A | 0 |
| Gloeocapsa | B | B | D |

TABLE VI--Continued

| | Small Farm Pond | Receiving Reservoir | Concrol Reservoir |
|---|---|---|---|
| Gomphosphaeria | 0 | 0 | A |
| Microcystis | C | 0 | 0 |
| Myrosarcina | C | A | A |
| Oscillatoria | D | E | D |
| Polycystis | C | 0 | 0 |
| Trichodemium | A | A | 0 |
| Euglenophyta - euglenoid | | | |
| Astasia | A | 0 | 0 |
| Euglena | E | D | B |
| Lopocinclis | D | D | B |
| Phacus | C | C | B |
| Rhabdomonas | B | B | D |
| Trachelomonas | D | D | D |
| Pyrrophyta - dinoflagelates | | | |
| Ceratium | 0 | B | A |
| Chroomonas | 0 | 0 | A |
| Glenodinium | D | D | C |
| Hypnodinium | 0 | C | A |
| Peridinium | A | D | D |
| Cryptophyceae - bi-flagelates | | | |
| Cryptomonas | D | E | D |
| Rhodomonas | 0 | 0 | A |




APPENDIX FIGURE 1. TOTAL NUMBER OF TAXA OF BENTHIC MACROINVERTEBRATES AND NUMBER OF ORGANISMS PER SQUARE METER.




APPENDIX FIGURE 2. TOTAL NUMBER OF TAXA OF PHYTOPLANKTERS AND NUMBER OF ORGANISMS PER MILLILITER

| 1 Accession Number | 2 Subject Field & Group | SELECTED WATER RESOURCES ABSTRACTS<br>INPUT TRANSACTION FORM |
|---|---|---|
| | 05C | |

5 Organization

EPA, Robert S. Kerr Water Research Center, Ada, Oklahoma

6 Title

EFFECTS OF FEEDLOT RUNOFF ON WATER QUALITY OF IMPOUNDMENTS

10 Author(s)

Duffer, William R.
Kreis, R. Douglas
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16 Project Designation

16080GGP07/71

21 Note

22 Citation

23 Descriptors (Starred First)

Reservoir,* Fishkill,* Ammonia,* Dissolved Oxygen,* Runoff,* Organic Wastes, Nutrients, Phytoplankton, Macrobenthos, Light Penetration,

25 Identifiers (Starred First)

Beef Cattle,* Feedlots,* Zooplankton, Solids Concentration

27 Abstract

A study was conducted to determine the effects of rainfall runoff from a beef cattle feedlot on the water quality of a small impoundment. Changes in chemical concentration of impounded water and changes in the community structure of aquatic organisms were measured and related to the amount and composition of feedlot runoff received. Water quality changes were also monitored in a nearby reservoir which received no feedlot runoff to serve as a control. Rainfall from feedlots was retained in collection ponds and pumped into the impoundment over a relatively short period of time, creating in effect a "slug" discharge condition. Changes in chemical concentration or population structure of organisms were not apparent for discharges of about one-part feedlot runoff to 40 parts receiving water. Runoff discharges for two pumping periods with each contributing one-fourth of the volume of the receiving water were shown to degrade water quality in the impoundment. Several significant chemical and biological changes occurred. The concentration of salts, solids, oxygen-demanding organic compounds and nutrients increased. Population levels decreased for organisms having negative tolerances for low dissolved oxygen and high ammonia concentrations. The most dramatic reduction in the biological community was the suffocation of about 90% of the game fish in the impoundment. Reduction in population levels of "stressed" organisms was followed by increased productivity of phototropes in response to higher nutrient concentrations. (Kreis-EPA, RSKWRC)

| Abstractor | Institution |
|---|---|
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WR:102 (REV JULY 1969)
WRSIC

SEND TO: WATER RESOURCES SCIENTIFIC INFORMATION CENTER
U.S. DEPARTMENT OF THE INTERIOR
WASHINGTON, D. C. 20240

U. S. GOVERNMENT PRINTING OFFICE: 1972—484-482/21

* GPO: 1969-359-339